Effects of Instruction in Advanced Planning on Computational Problem Solving in a Group Environment

ADAM GROBMAN – ILLINOIS MATHEMATICS AND SCIENCE ACADEMY

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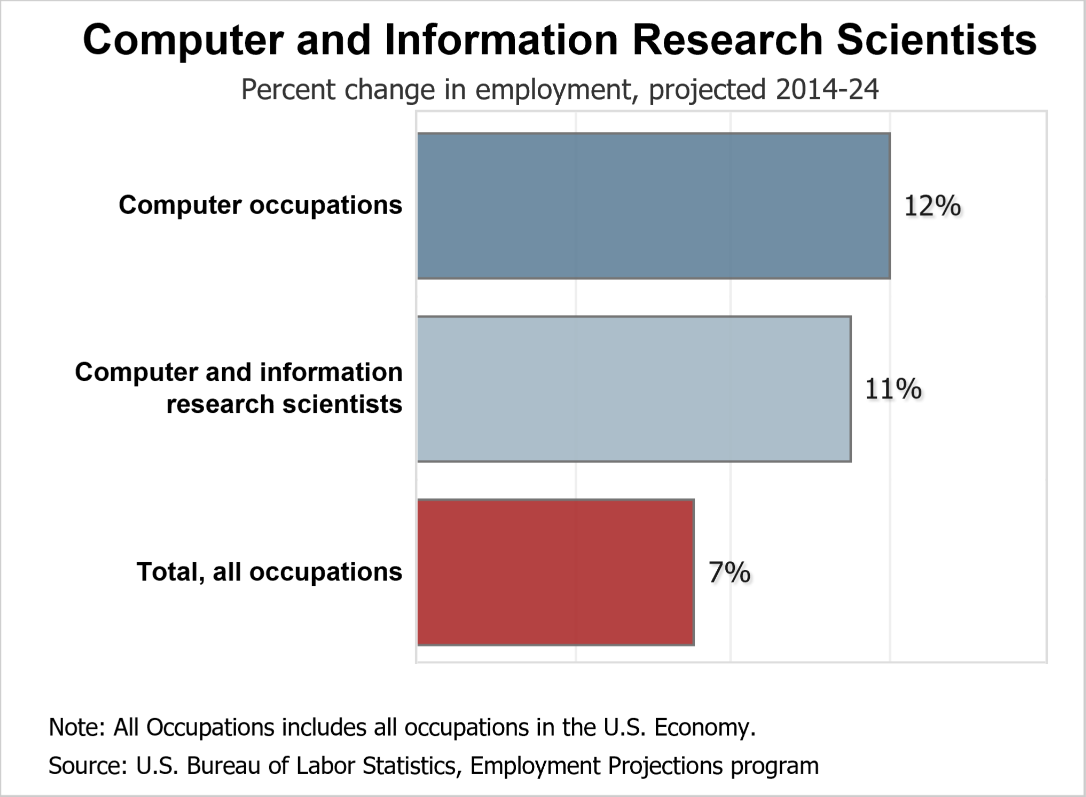
Introduction

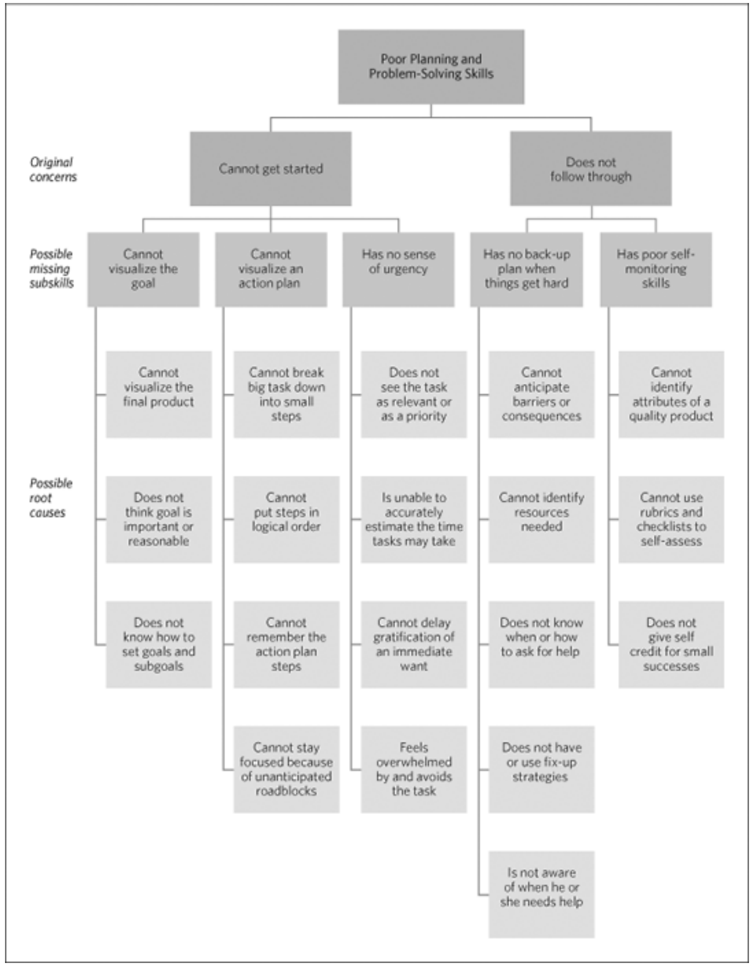
- Computer science (CS) is a rapidly growing field
- By 2020, there will be a surplus of 1,000,000 jobs (Colby, 2015)
- Expected growth in jobs of 12% from 2014 to 2024 (Bureau of Labor Statistics, 2016)
- Computational thinking improves conceptualization across many domains (Wing, 2006)



From "Computer and Information Research Scientists," by Bureau of Labor Statistics, 2016 (http://www.bls.gov/ooh/computer-and-information-technology/computer-and-information-research-scientists.htm). In the public domain.

Introduction

- CS is difficult for students to learn
- Requires high order skills (Barak, 2013)
    - Applying
    - Analyzing
    - Creating
- Requires clear goals and plans
    - Difficult for many students (Searle, 2013)



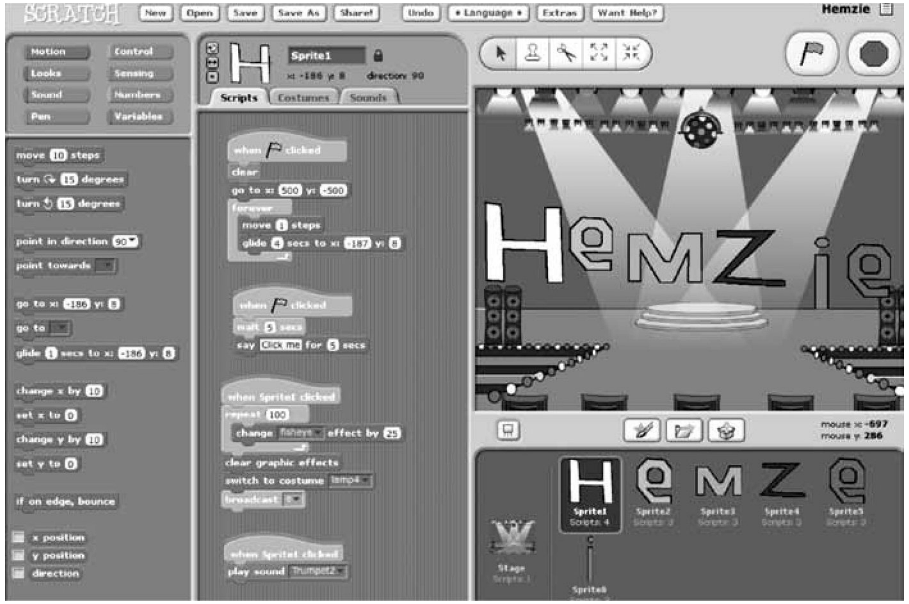
From *Causes and Cures in the Classroom: Getting to the Root of Academic and Behavior Problems* (p. 22), by M. Searle, 2013, Alexandria, VA: ASCD. Copyright 2013 by ASCD. Reprinted with permission

Inquiry Question

HOW (IF AT ALL) DOES EXPLICIT INSTRUCTION IN ADVANCED PLANNING AFFECT COMPUTATIONAL PROBLEM SOLVING IN A GROUP?

Methodology

- We created the "Scratch That: Computational Thinking with Scratch" educational outreach program
- Added a lesson on the advanced planning strategies



From "Using Scratch: An Integrated Problem-solving Approach to Mathematical Thinking," by N. Calder, 2010, *Australian Primary Classroom*, *15*, p. 10. Copyright 2010 by the Australian Association of Mathematics Teachers. Reprinted with permission.

Methodology

- Children whose schools or scouting troops visited for field trips (*N* = 54) completed surveys about their typical education environment and their experience with a group problem solving activity during the lesson
  - We taught certain students (*n* = 27) the experimental lesson
  - Others (*n* = 27) were taught the standard curriculum
- Students' responses analyzed using *t* tests and Correlation-Regression Analyses

Human and Animal Subjects Review Status

- Pursuant to federal law, proposal submitted to the IMSA Human and Animal Subjects Review Committee
  - Declared as exempt from oversight
- All students treated ethically
  - Data anonymized
  - Informed assent
  - Right to withdrawal

From "Safety at ACDC," by Argonne National Laboratory, 2012 (https://www.flickr.com/photos/argonne/10825678315/in/album-72157636090524023/). Reprinted with permission.

Results

- Mean perception of the outcomes of the problem solving process were higher in the control group (Figure 1)
  - Mean perception of validity of solution not significantly higher in control group, $t(52) = .105$, $p = .917$
  - Mean perceptions of participation and understanding significantly higher in control group, $t(41) = 2.186$, $p = .035$; $t(43) = 2.042$, $p = .047$
- Mean number of students utilizing the advanced planning strategies (goal setting, action planning, and division of labor) was not different between groups, $t(52) = -1.119$, $p = .268$; $t(52) = -0.536$, $p = .594$; $t(50) = 1.358$, $p = .180$

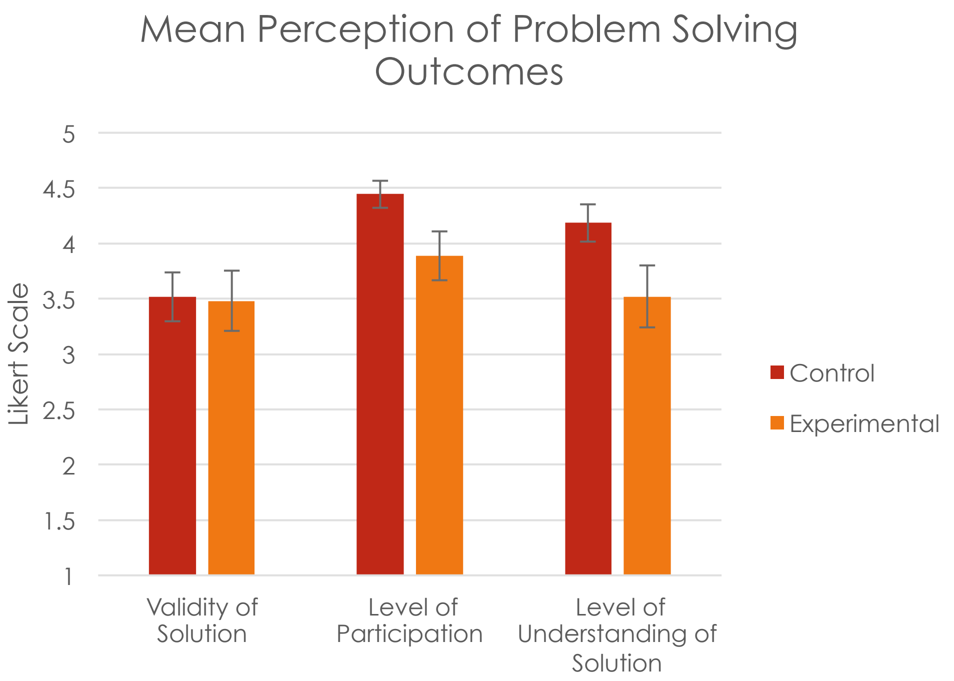


Figure 1. Mean response on Likert scale for perceived characteristics of the problems solving process in both the control and experimental groups. Error bars depict ±1 *SE*.

Results

- Positive correlations exists between use of goal setting or division of labor and the perceived validity of a solution (Table 1)
  - All other correlations not statistically significant

Table 1
Correlations between Usage of Advanced Planning Strategies and Perceptions of Problem Solving Outcomes

Advanced Planning Strategy	Validity of Solution	Active Participation	Student Understanding of Solution
Goal Setting	$r(52) = .301^*$	$r(52) = .134$	$r(52) = .127$
Action Planning	$r(52) = .233$	$r(52) = .052$	$r(52) = .156$
Division of Labor	$r(50) = .286^*$	$r(50) = .181$	$r(50) = .251$

Note: $^*p < .05$

Conclusions

- Student should set goals and divide labor while working on computation problems in groups
- Explicitly teaching the advanced planning strategies does not affect their usage
- Teaching advanced planning strategies decreased student's perceived achievement

Discussion/Future Studies

- Advanced planning strategies should not be taught
  - Student perception of performance strongly correlated with teacher analysis (Chang, Tseng, & Lou, 2012)
  - National Education Commission on Time and Learning (2005) found limited school time affects learning when teachers try to cover too much
- We still need to learn more about CS education
  - Some schools are teaching CS without even touching a computer (Paul, 2015)
    - Is this effective?

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References

- Argonne National Laboratory. (2012). Safety at ACDC. Retrieved from https://www.flickr.com/photos/argonne/10825678315/in/album-72157636090524023/
- Barak, M. (2013). Teaching engineering and technology: Cognitive, knowledge and problem-solving taxonomies. *Journal of Engineering, Design and Technology*, *11*, 316–333. http://dx.doi.org/10.1108/JEDT-04-2012-0020
- Bureau of Labor Statistics. (2016). Computer and information research scientists. *Occupational Outlook Handbook*. Retrieved from http://www.bls.gov/ooh/computer-and-information-technology/computer-and-information-research-scientists.htm
- Calder, N. (2010). Using Scratch: An integrated problem-solving approach to mathematical thinking. *Australian Primary Mathematics Classroom*, *15*(4), 9–14. Retrieved from http://eric.ed.gov/?id=EJ906680
- Chang, C. C., Tseng, K. H., & Lou, S. J. (2012). A comparative analysis of the consistency and difference among teacher-assessment, student self-assessment and peer-assessment in a Web-based portfolio assessment environment for high school students. *Computers & Education*, *58*, 303–320. http://dx.doi.org/10.1016/j.compedu.2011.08.005
- Colby, J. (2015). 2,445 hours of code: What I learned from facilitating hour of code events in high school libraries. *Knowledge Quest*, *43*(5), 12–17. Retrieved from http://knowledgequest.aasl.org/dive-into-summer-learning-with-the-mayjune-2015-issue/
- Paul, A. M. (2015). Teaching computer science-without touching a computer. *The Education Digest*, *80*(5), 23–26. Retrieved from http://www.eddigest.com/sub.php?page=23
- Searle, M. (2013). Planning and problem solving: Failing to launch and follow through. In *Causes & cures in the classroom: Getting to the root of academic and behavior problems*. Alexandria, VA: ASCD. Retrieved from http://www.ascd.org/publications/books/113019.aspx
- Wing, J. M. (2006). Computational thinking. *Communications of the ACM*, *49*(3), 33–35. http://dx.doi.org/10.1145/1118178.1118215